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[LITD 4: Electron Tubes and Display Devices]

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Indian Standard
METHODS OF MEASUREMENTS ON CAMERA TUBES

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METHODS OF MEASUREMENTS ON CAMERA TUBES

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0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 23 November 1973, after the draft finalized by the Electron Tubes Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 In preparing this standard, assistance has been derived from IEC Pub 151 - 26(1971) 'Measurements of the electrical properties of electronic tubes, Part 26 Methods of measurement for camera tubes', issued by the International Electrotechnical Commission.

0.3 This standard is one of a series of Indian Standards on cathode ray and TV picture tubes. A list of Indian standards so far published in this series is given on the fourth cover page.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers methods of measurements relating to camera tubes.

2. TERMINOLOGY

2.1 For the purpose of this standard, the term and definition covered in IS : 1885 (Part IV/Sec 7) - 1973†.

3. BASIC THEORY

3.1 Image Orthicon

3.1.1 The image orthicon is a vacuum tube containing a photo-emissive surface, a storage target, an electron gun and an electron multiplier.

*Rules for rounding off numerical values (*revised*).

†Electrotechnical vocabulary : Part IV Electron tubes, Section 7 Camera tubes.

3.1.2 The target is operated at a potential very near to that of the cathode of the electron gun.

3.1.3 By means provided externally, electrons, released by an optical image projected on to the photo-emissive surface, are focused upon the storage target to produce a pattern of charges corresponding locally in density to the luminance values of the original scene.

3.1.4 The scanning beam, approaching the target from the side away from the photo-emissive surface, is modulated by this charge pattern and thereafter is deflected into the electron multiplier from which it emerges as the video signal.

3.2 Vidicon

3.2.1 The vidicon is a vacuum tube having a photoconductive target and an electron gun.

3.2.2 The target is operated at a potential near to that of the cathode of the electron gun.

3.2.3 An optical image projected on to the photoconductive target causes its resistance to change proportionally, thus permitting a potential applied to its transparent conducting backing plate to appear on its scanned side as a pattern of charges corresponding locally in density to the luminance values of the original scene.

3.2.4 When scanned, the charge pattern is neutralized point to point to produce a succession of current changes in the backing plate from which they emerge as the video signal.

4. MEASURING EQUIPMENT AND ACCESSORIES

4.1 Optical System — The optical system consists of a lens (including a lens iris) and optical filters. Its performance shall be specified and shall not impair the measurement. The optical system, the yoke assembly and their mechanisms are positioned in such a way that their axes coincide with the tube axis. A mechanism to focus the optical image on the photosensitive surface should be provided.

Note — The camera tube being measured should be shielded from undesired light.

4.2 Yoke Assembly — In view of the important effect the yoke assembly may have on the overall performance of the tube, it is necessary that the yoke assembly be identified when measurements are quoted. The yoke is to be magnetically shielded from external fields.

4.2.1 *Alignment Coils* — The alignment coils accomplish the alignment of the beam from the gun by a transverse magnetic field. The alignment field strength and direction are adjusted by varying the coil currents.

4.2.2 *Deflecting Coil Assembly* — This consists of a pair of coils for vertical deflection and a pair of coils for horizontal deflection. They are positioned so that their axes are substantially at right angles to each other. In order to scan the electron beam along the surface of the target of the camera tube, saw-tooth waveform currents of field frequency and line frequency are fed into the vertical and the horizontal deflection coils respectively. For camera tubes having an image section, this section should be shielded as completely as possible from the deflecting magnetic field in order to prevent undesirable effects on the image section.

4.2.3 Focusing coil provides a magnetic field which together with the electrostatic field, focuses the electron beam from the gun on to the target. It consists of a long cylindrical solenoid which provides a magnetic field essentially parallel to and symmetrical with the axis of the camera tube. For the image orthicon, the focusing coil has an additional function to focus the photoelectrons onto the target.

A variable direct current source is provided in order to adjust the magnetic field strength to the specified value. It is essential that the source of current be well stabilised.

4.2.4 *Shielding for Tubes with Electrostatic Focus and/or Deflection* — The tube is placed in a metallic shield of good magnetic permeability giving sufficient protection over all the tube length against extraneous magnetic fields and variable electric fields which could effect resolution or deteriorate output signal uniformity.

4.3 Deflection Generators — The deflection generators supply saw-tooth waveform and currents (or voltages) of field frequency and line frequency to the deflecting coils (or deflection electrodes) and shall fulfil the following requirements.

4.3.1 *Scanning Size Control* — The deflection generators shall provide a scanning size control so that the beam can be adjusted to scan over the specified area of the target.

4.3.2 *Retrace Time* — The retrace time of both horizontal and vertical saw-tooth waveform currents (or voltages) should not exceed the respective specified blanking times.

4.3.3 *Scanning Position Control* — The deflection generators shall provide scanning position controls so that the beam can be adjusted to scan on the specified portion of the target.

4.3.4 *Linearity of Scan* — The deflection generators shall ensure a linear scan across the target in the direction of both axes.

4.4 Video Amplifier System — This consists of a video pre-amplifier and a video output amplifier. The output signal of the amplifier is fed into a picture monitor and an oscilloscope. The frequency response characteristic of the video amplifier system shall be specified.

4.5 Picture Monitor — The picture monitor is an instrument which displays on a television picture tube a picture which corresponds point by point with the signal read-out of the camera tube.

4.6 Waveform Monitor — The waveform monitor is an instrument incorporating an oscilloscope tube on which the various waveforms associated with the camera tube and yoke can be displayed. It is used in association with the picture monitor to set up and measure the operating parameters of the camera tube. The parameters of the waveform monitor shall not limit the accuracy of the measurement. The waveform monitor fitted with a graticule shall be equipped with a line selector which indicates the location of the selected with a line on the picture monitor by brightening or darkening the luminance of the corresponding line in the viewed picture.

4.7 Shading Correction Circuit — A circuit by means of which any shading in the reproduced picture may be corrected, usually by superimposing saw-tooth and/or parabolic shaped signals of both field and line frequency upon the video signal.

4.8 Light Source

NOTE — *See also* IS : 7146 (Part I)-1973*.

4.8.1 A tungsten filament standard lamp calibrated for intensity and spectural energy distribution at a colour temperature of 2 854°K or other tungsten filament lamps calibrated against the standard lamp shall be used for measuring the spectral sensitivities and relative spectral sensitivities of the camera tube.

4.8.2 For characteristics not affected by the spectral distribution of the light from the source, light sources other than those indicated in **4.8.1** may be used.

4.9 Test Charts — For measuring the electrical performance and characteristic of the camera tubes, test charts are used which may be of the reflecting or transmitting type but for measuring purposes, the latter is preferred. In both cases, the test chart shall be uniformly illuminated by the light sources and peak whites should be of the same luminance. Commonly used test charts are as follows.

4.9.1 *Test Chart A* — It is a general test chart for setting up a test channel. It generally includes a grey scale, resolution wedges and larger area of differing density.

4.9.2 *Test Chart B* — It is a resolution test chart based upon groups of parallel black and white lines giving rise to specific video frequencies when scanned.

4.9.3 *Test Chart C* — It is a grey scale test chart which may be of logarithmic C(1), or linear C(2) type and of a stated contrast law.

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*Methods of measurements on photosensitive devices: Part I Basic considerations.

4.9.4 *Test Chart D* — It is a picture defect test chart consisting of contour lines dividing the picture area into zones of varying importance.

4.9.5 *Test Chart E* — It is a linearity test chart defining a precisely spaced pattern of horizontal and vertical lines having tolerance marks at their intersections.

4.9.6 *Test Chart F* — It is a test chart for checking edge effects and vertical resolution consisting of a centrally positioned white cross on a dark background of 3 percent white.

5. CONDITIONS OF MEASUREMENT

5.0 Caution — It is universally recognized that the performance of a television camera tube can, in many cases, only be assessed with the human eye. The assessment process is largely subjective, and for this reason, any recommendation for objective measurements can be expected to be somewhat controversial.

5.1 All Camera Tubes — Parameters are set as specified in the individual specification for each camera tube using Test Chart A. Unless otherwise specified, the conditions specified in **5.1.1** to **5.1.7** should be established.

NOTE 1 — Once the test channel has been correctly set-up, it will not be permissible to change the conditions under which the measurements are carried out unless such a change is specifically mentioned in the clause concerned.

NOTE 2 — It is not intended that this clause should describe the full set-up procedure nor does it necessarily represents operating practice. The various operations described are not listed in any particular or preferred sequence.

5.1.1 *Operating Position* — The tubes shall be accurately positioned in the yoke assembly.

5.1.2 *Focusing Magnetic Field* — To define its direction, the north pole of a magnetic needle held outside and near to the axis of the energized focusing coil shall be attracted to the photocathode end.

5.1.3 *Alignment* — The alignment field is adjusted so that the information at the centre of the picture is observed to undergo no displacement as the beam focus is varied through the point of focus. Further adjustment of the alignment field is then made, if necessary, to optimize the picture. The alignment field shall be within specified limits.

5.1.4 *Scanning* — The diagonal, aspect ratio and angular orientation of the scanned area shall be precisely defined. The centre of the raster shall be aligned with the tube axis.

5.1.5 *Lens Aperture (Lens Stop)* — Lens aperture (Lens Stop) shall be adjusted until the high light in the test chart comes to the specified position on the light-signal transfer characteristic.

NOTE — The lens stop has to remain in a range known to give optimum resolution; if necessary, grey filters or increased illumination have to be used to ensure this.

5.1.6 The optical focus is adjusted to obtain the best resolution.

5.1.7 *Operating Temperature* — The camera tube envelope temperature and the temperature differences along the envelope are to be held within the specified limits.

5.2 Image Orthicon — Parameters are set as specified in the individual specification for the image orthicon using Test Chart A. Unless otherwise specified, the conditions specified in **5.2.1** to **5.2.8** should be established.

5.2.1 *Target Mesh Voltage* — The target mesh voltage is set to a specified value above cut-off.

5.2.2 *Beam Control-Grid (G1) Operating Voltage* — At the specified target voltage, the G1 potential is increased until the beam just discharges the highlights in the picture.

5.2.3 *Beam Focus (G4) Voltage and Image Focus Voltage* — The beam focus (G4) voltage and the image focus voltage are adjusted for the best resolution within their specified ranges.

5.2.4 *Persuader (G3) Voltage (Multifocus)* — The persuader (G3) voltage is adjusted for the best compromise between the maximum output signal and the least shading.

5.2.5 *Shading Correction* — The shading controls are adjusted for optimum flatness of signal with no light incident upon the photocathode.

5.2.6 *Decelerator (G5) Voltage* — The decelerator (G5) voltage is adjusted for the best compromise between optimum resolution, geometry and minimum corner shading. In cases where the field-mesh potential is independently variable, it is used in conjunction with G5 to obtain the best results.

5.2.7 *Accelerator (G6) Voltage* — The accelerator (G6) voltage is adjusted for the best compromise between minimum S-distortion, minimum ghost effect and optimum focus of the picture.

5.2.8 *Blanking* — The blanking signal is applied to the target with the specified voltage.

5.3 Vidicon — Parameters are set as specified in the individual specification for the vidicon using Test Chart A. Unless otherwise specified, the conditions specified in **5.3.1** to **5.3.4** should be established.

5.3.1 *Signal Electrode Voltage, Lens Aperture (Lens Stop) and Beam Control-Grid Voltage* — The signal electrode voltage is set to a value which gives a specified dark current. The lens aperture is adjusted to give a specified signal current with the beam control-grid voltage always adjusted just to discharge the highlights.

5.3.2 *Beam Focus Voltage* — The beam focus voltage is adjusted, within the specified range, for the best resolution.

5.3.3 *Shading Correction* — The shading controls are adjusted for optimum flatness of signal.

5.3.4 *Blanking* — The blanking signal is applied to the cathode or G1 with the specified voltage.

6. METHODS OF MEASUREMENT

6.0 The thermionic cathode is taken as a reference point for all voltage measurements.

6.0.1 *Caution* — Measurement results are strongly dependent upon operating conditions and test equipment, and may not be reproducible if either is changed.

6.1 All Camera Tubes — The measurements described in **6.1.1** to **6.1.14** are applicable to all types of camera tubes and are made under the conditions of measurement described in **5**.

6.1.1 *Signal Current* — For this measurement, Test Chart B is used. Then, using a line selector to portray on the waveform monitor a single black/white step, its amplitude is measured. This can be converted into a value for the signal current.

Alternatively the signal current can be measured using a dc instrument, appropriately located in the signal electrode lead, together with uniform illumination and taking into account the blanking periods.

6.1.2 *Resolution* — Resolution is measured by comparing the amplitude response obtained from a series of grating patterns, calibrated for different television standards, and having black and white bars of equal width and of a contrast ratio of at least 100 : 1, with that of a coarse pattern corresponding to a frequency of about 100 kHz. The contrast ranges and the mean luminance of the patterns are equal.

The resolution is measured at various specified positions on the picture.

6.1.3 *Transfer Characteristic* — The tube is focused on test chart C(1) or C(2), with line selection through the grey scale and the signal amplitude is measured on the waveform monitor for each step at the same point on the camera tube by moving the camera or the test chart.

A graphical representation of the transfer characteristic is obtained by plotting signal amplitude as a function of its associated step luminance.

No circuity for modifying the grey scale shall be used during the measurements.

6.1.4 *Afterimage (Picture Sticking or Burn-in)* — The tube is focused on a test chart, such as Test Chart A, for the specified period, then the camera is moved to a uniform light grey background. The duration from the instant the camera is moved till the instant when the image reduces to the specified level is measured.

6.1.5 *Microphony* — No completely satisfactory test or measurement has yet been devised, but one possibility is as follows : observation is made of the

amplitude, frequency and duration of the venetian blind type of shading signal produced on the picture monitor when a small mechanical or acoustical shock is applied to the tube.

NOTE — To check whether the pre-amplifier adds to the microphonic output the beam is reduced to zero and the test repeated.

6.1.6 *Hum* — With the tube looking at a uniformly illuminated surface of specified luminance, the picture field frequency is adjusted to differ slightly from the frequency of the mains supply to the tube filament. The output signal is then examined for hum. Hum caused by inadequate heater-cathode insulation may be observed by interrupting the voltage supply to both ends of the heater simultaneously for short intervals of less than 1 second and nothing the difference in hum amplitude.

6.1.7 *Beam Control Grid (G1) Cut-Off Voltage* — The G1 cut-off voltage is obtained by decreasing the beam control grid potential until just no video information can be obtained from the tube. This value is then measured.

6.1.8 *Picture Blemishes* — Using Test Chart D and a specified level of illumination the blemishes and their distribution are measured on the waveform monitor or picture monitor or both and shall not exceed certain limits. The effects of spots can be given by quoting the spot nuisance value.

6.1.9 *Edge Effect* — The tube is exposed to Test Chart F. The amplitude of any overshoot in the signal caused by the tube on the various edges of the picture is measured and related to the amplitude of the signal for picture white.

6.1.10 *Output Capacitance* — This is a normal bridge measurement of the capacitance between the signal electrode and all other electrodes strapped together. It is usually made with the tube separate from the camera.

6.1.11 *Spectral Sensitivity* — For this measurement, a monochromator or other equivalent radiation source is used. The spectral sensitivity is obtained by measuring the radiant sensitivity for monochromatic radiation, with respect to the wavelength, over the specified range.

The spectral sensitivity is presented either relatively, in which case ordinates are expressed as a percentage of a chosen value (usually the maximum), or absolutely, in which case they are expressed as microamperes per microwatt of the incident illumination (*see* Fig. 1 for a typical curve for image orthicons).

If the signal current is not proportional to the illumination, the spectral sensitivity shall be measured at a constant signal current which shall be specified. For each chosen wavelength, the radiation input required to give the specified signal current is measured, then the spectral sensitivity is presented as a curve showing the relationship between the reciprocal of this radiation input, and its wavelength.

NOTE — It is also necessary to specify the wavelength increment emerging from the monochromator, and whether the slit-width is adjusted to correspond with the nominal wavelength. In general, the slit-width shall be adjusted along with the wavelength to give a constant wavelength interval.

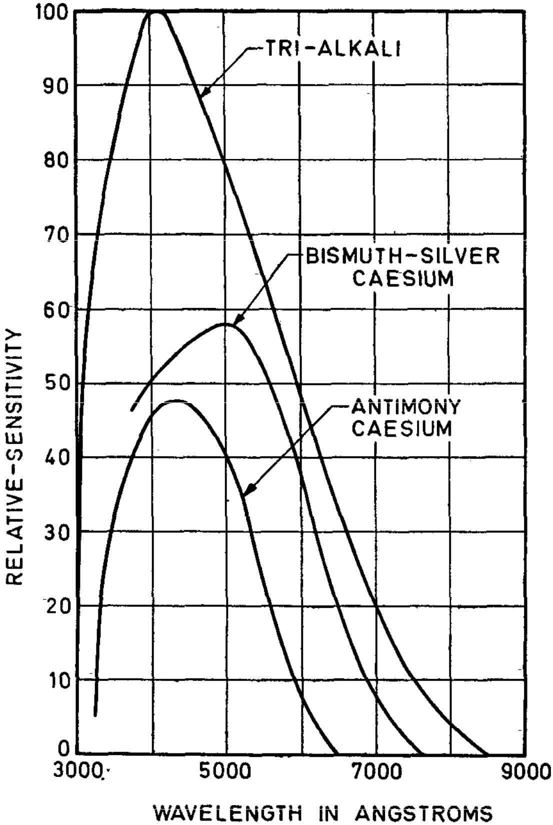

FIG. 1 SPECTRAL RESPONSE CURVES OF TYPICAL PHOTO CATHODES USED IN IMAGE ORTHICONS

6.1.12 *Threshold (Useful) Sensitivity* — Using uniform illumination, the threshold (useful) sensitivity shall be measured by determining the luminous flux necessary to obtain a stated signal-to-noise ratio in the output.

The figure obtained will be a function of the signal-to-noise ratio chosen. It will therefore be necessary to perform this measurement at various levels of light input. Graphical plots of the luminous flux against the signal-to-noise ratio thus obtained give the value required.

6.1.13 *Geometrical Nonlinearity* — Test Chart E is used and its image compared with an electronically generated raster. Any deviations are expressed as percentages of picture height/width.

6.1.14 *Lag*

6.1.14.1 *Decay lag* — For a specified time, the tube is exposed to a test chart comprising a small white area surrounded by a dark background. The amplitude of the white signal (^{i}Sig. 1) is measured. The illumination is then cut off and the white signal current (^{i}Sig. 2) is measured after the time stated.

The lag is calculated using the following formula:

$$\text{lag} = \frac{^{i}\text{Sig. 2}}{^{i}\text{Sig. 1}} \times 100 \text{ (percent)}$$

6.1.14.2 *Build-up lag* — After the tube has been operating under capped-up conditions for a specified time, the same illumination as in **6.1.14.1** is instantaneously applied and then the amplitude of the white signal (^{i}Sig. 3) is measured after a stated time *t*.

The build-up lag is calculated using the following formula:

$$\text{lag (t)} = \frac{^{i}\text{Sig. 3}}{^{i}\text{Sig. 1}} \times 100 \text{ (percent)}$$

6.1.15 *Signal-to-Noise Ratio* — No completely satisfactory method exists for the measurement of the signal-to-noise ratio, but method 1, in skilled hands, will give a good indication of the signal-to-noise ratio, observed from the camera as a visual impression. Method 2 is a simple method of obtaining an accurate measurement of signal-to-noise ratio, but it may not in all cases give a true indication of the noise observed.

6.1.15.1 *Method* 1 — The tube is focused on the Test Chart A and a line selected through the specified portion. The peak-to-peak noise in the black (ignoring occasional extreme digressions) is measured and recorded in the specified bandwidth.

The peak-to-peak signal is divided by the peak-to-peak noise, and this value multiplied by the factor of 6 to convert the peak-to-peak noise signal to rms noise.

This ratio is taken as the signal-to-noise ratio.

6.1.15.2 *Method* 2 — Using uniform illumination, the signal-to-noise ratio is measured with a specified commercially available instrument, based on the direct measurement of the rms value of the noise. The method generally employs a narrow band-pass filter, the centre frequency of which can be placed accurately in the ' dead ' area between the signal harmonies of the line frequency. The energy in these areas in the rms noise, all components caused by picture, shading, synchronization, etc, being rejected, and by simple comparison with a standard noise source using an rms indicator, a value of the noise at any given frequency within the band can be obtained.

6.2 Image Orthicon — The measurements described in **6.2.1** to **6.2.8** are applicable to image orthicon, and are made under the conditions of measurement described in **5**.

6.2.1 *Target Cut-Off Voltage* — The target cut-off voltage is measured after reducing the target mesh potential to a value just below which no video information can be obtained from the tube.

6.2.2 *Beam Control Grid (G1) Modulation Range* — The G1 modulation range is measured by taking the difference between the G1 operating voltage and the G1 cut-off voltage.

6.2.3 *Charging Current* — Using uniform illumination, at least one lens stop above the knee and a beam current slightly higher than that necessary for just discharging the target, measure the current change occurring in the target lead when the scanning beam is cut-off; this is the charging current.

NOTE — When calculating the storage capacitance of the target, a corrected value of the charging current shall be used by taking into account the total duration of all blanking periods.

6.2.4 *Photocathode Integral Sensitivity* — The voltage specified in the individual specification of the camera tube is applied between the photocathode and the other electrodes, and the central area of the photocathode is uniformly illuminated by the light source (*see* **4.8.1**). The diameter of the illuminated area should be more than one-fifth of the effective diameter of the photocathode. Then the photocurrent is measured and the sensitivity of the photocathode (for example, in microamperes per lumen) is obtained by taking the quotient of the measured photocathode current by the relevant incident luminous flux.

6.2.4.1 *Caution* — It is necessary to use low illumination to avoid resistivity effects of the photocathode.

6.2.5 *Photocathode Radiant Sensitivity* — This is measured as in clause **6.2.4** except the photocathode current is divided by the incident radiant power instead of by the luminous flux (*see* **6.2.4.1**).

6.2.6 *Knee Sensitivity* — Using uniform illumination, the light flux necessary to operate the tube at the knee of the light-signal transfer characteristic is determined.

6.2.7 *Signal Uniformity* — Using uniform illumination at various specified levels, signal uniformity is measured as the amplitude of its containing envelope on the waveform monitor and expressed as a percentage of peak white signal.

The following levels are often used:

a) With uniform black background, that is, with no incident light on the photocathode;
b) With illumination one lens stop below the knee point; and
c) With illumination one lens stop above the knee point.

6.3 Vidicon — The measurements described in **6.3.1** and **6.3.2** are applicable to vidicons, and are made under the conditions of measurement described in **5**.

6.3.1 *Signal Uniformity* — Using uniform or no illumination, signal uniformity is measured as the amplitude of its containing envelope on the waveform monitor and expressed as a percentage of peak white signal.

6.3.2 *Luminous Sensitivity* — The target voltage is set to give a specified dark current, the input light level is adjusted to a specified value, the beam is adjusted until the highlights are just discharged. The signal current is measured and the luminous sensitivity calculated.

The result is expressed as the ratio of the signal current in microamperes to the illumination in lumens.